Assessment of high-elevation lakes exceeding critical loads of atmospheric nitrogen deposition in the Greater Yellowstone Area

David Espinoza

San Francisco State University

February 2019 – June 2019

Advisor: Leora Nanus, Ph.D.

Assistant Professor, San Francisco State University

Report Submitted on June 3, 2019

Table of Contents

Acknowledgements

This project was supported by Hispanic-Serving Institution's Education Program Grant no. 2015-3842224058 from the USDA National Institute of Food and Agriculture. I would like to thank Dr. Leora Nanus for the opportunity of working alongside her on her research. The experience has taught me numerous new skills that I will continue to grow and be beneficial in the future. I wish to thank Julian Logiudici, whose knowledge on the subject matter helped bring new understanding of the importance of the research work. I would also like to acknowledge the U.S. Forest Service for building and maintaining open source data for the public.

Executive Summary

Over the course of five months I have been working under Dr. Leora Nanus and was tasked with creating and managing an entirely new geodatabase within ESRI's ArcGIS Pro software. I would bring in new and historical data that was collected from multiple sources into an easily comprehensible model. I was also tasked with compiling existing data from high-elevation lakes and watersheds from across the greater Yellowstone area, which included but not limited to, several high-altitude lakes located within Bridger-Teton, Caribou-Targhee, Custer-Gallatin, and Shoshone National Forests. Furthermore, I analyzed and evaluated temporal trends in chemical concentrations for the National Forest. I assisted in the development of critical loads and exceedance maps that could be understood by a broad audience from various professional backgrounds.

Project Objectives

The project's main focus was to have interns work with chemistry data of high altitude lakes within the greater Yellowstone area. The problem we faced was to attempt to measure and predict the lakes critical load exceedances of atmospheric nitrogen deposition. The lake chemistry data was collected from many high altitude lakes in the greater Yellowstone area over long periods of time. From working with the data on ESRI's GIS program we were able to gain better knowledge of the innerworkings of environmental management on how they were to approach such a problem. Working with the project data helped bring a better understanding of the watersheds that are in the greater Yellowstone area and the impacts that atmospheric pollution may have on them. By applying our knowledge of GIS and learning how to use more of the software it allowed us to gain more experience in the field of environmental analysis in a resource management context.

By gaining first hand experience through working with current field data this work has allowed me to see what it might be like working for a larger corporation. My goals for this project were fairly simple in which I wanted to gain experience using my skills with GIS in real world settings, I aimed to learn as much as I could about the subject matter at hand and have a better understanding of what it might be to work in this field. I believe that through the time I was working with Dr. Nanus I was able to gain a lot of the on hands experience I was expecting to achieve while working as an intern. The work that I was tasked to do allowed me to apply

what I had already known while gaining more skills and knowledge on the subject matter using GIS.

Project Approach

Working as a student intern on data for atmospheric nitrogen deposition using GIS was a big step in achieving my goals for the project. I was already very familiar with the program from courses taken through San Francisco State University and they caught my interest so much that I enrolled in the College of Extended Learning at San Francisco State University to earn a GIS certificate. When going through the interview process I already knew that an internship with the Water Resource and Policy Initiatives, working under Dr. Nanus, would allow me to apply the knowledge of GIS. I was also faced with hurdles being tasked with completing projects I had very little idea of how to complete. These tasks were some of the best for me since it forced me to have to better understand how to use the data and the software in order to get the desired results.

While working with all the data being given to me I took it upon myself to try and learn as much as I could on the subject matter of nitrogen deposition for high altitude lakes in order to have a better understanding of where the information was coming from and why it was important. I was able to do this by reading past work that Dr. Nanus has had a hand in doing research for and writing listed in appendix A. Working with current data, having weekly task, and assisting with what I could do to the best of my knowledge for the project allowed for me to have some work experience. I was able to learn how to use geostatistical analysis and apply it to a study area. I had to research and attempt many different tools and methods for reaching the tasks goals I was given. It allowed for me to put myself in a position that someone who is doing this as a career may find themselves in.

Project Outcomes

For this project I was required to compile raw data from high elevation lakes and watersheds in order to develop a usable geodatabase. The geodatabase used geostatistical analysis of the lake chemistry data that was surveyed over a long period of time. The main focus of the study was to observe and model nitrogen deposition and critical loads of watersheds and high-altitude lakes from atmospheric deposition within the greater Yellowstone area. The lake

chemistry data was compiled thanks to the cooperation of many different organizations. From the lake data brought in from previous studies we georeferenced them to their appropriate locations, appendix B, to aid in running interpolations. From the most recent and up to date data of the lake chemistry from several sites in the greater Yellowstone area we were able to validate the models made from previous studies and current ones.

There were many obstacles that had to be overcome in order to complete the project. Though much of the data was already on hand there needed to be data sourced from other organizations to complete it. One lesson learned over the course of the internship was becoming familiar with the United States Geological Survey's national map viewer. From the website I learned how to properly select and download items such as digital elevation models and national hydrographic datasets. It was a learning experience figuring out how the website worked and being able to bring in the data to GIS in order to have it work with our data.

Conclusion

Utilizing ESRI's ArcGIS Pro we were able to put together a geodatabase of high-altitude lake chemistry data from the survey work done. We also brought in multiple models from previous studies done to compare them to the most current lake chemistry data for validation of how accurate the models were. Additional variables were brought in to update the most current models such as digital elevation models and national hydrographic datasets. Once we had all the necessary information in a workable format that could interact with one another on GIS we were able to validate the critical loads and exceedance maps for the greater Yellowstone area based on the results. I had set some personal goals of my own to be able to takeaway some valuable experience from this internship and I believe that with the help I received from the people I worked with that I was able to gain the most out of my time working on this internship. I know that with the new knowledge and skills that I have gained from this wonderful experience that I will be able to apply them to any new career prospects that I may have in the future.

Appendix A

Nanus L., Clow D.W., Saros J.E., Stephens V.C., Campbell D.H. (2012). Mapping critical loads of nitrogen deposition for aquatic ecosystems in the Rocky Mounatins, USA. *Environmental Pollution.* (2012). 166. 125-135

Nanus L., McMurray J.A., Clow D.W., Saros J.E., Blett T., Gurdak T.T., (2017). Spatial variation of atmospheric nitrogen deposition and critical loads for aquatic ecosystems in the Greater Yellowstone Area. *Environmental Pollution.* (2017). 223. 644-656.

Nanus L., Campbell D.H., Lehmann C.M.B., Mast M.A. (2018). Spatial and temporal variation in sources of atmospheric nitrogen deposition in the Rocky Mountains using nitrogen isotopes. *Atmospheric Environment.* (2017). 176. 110-119.

Appendix B

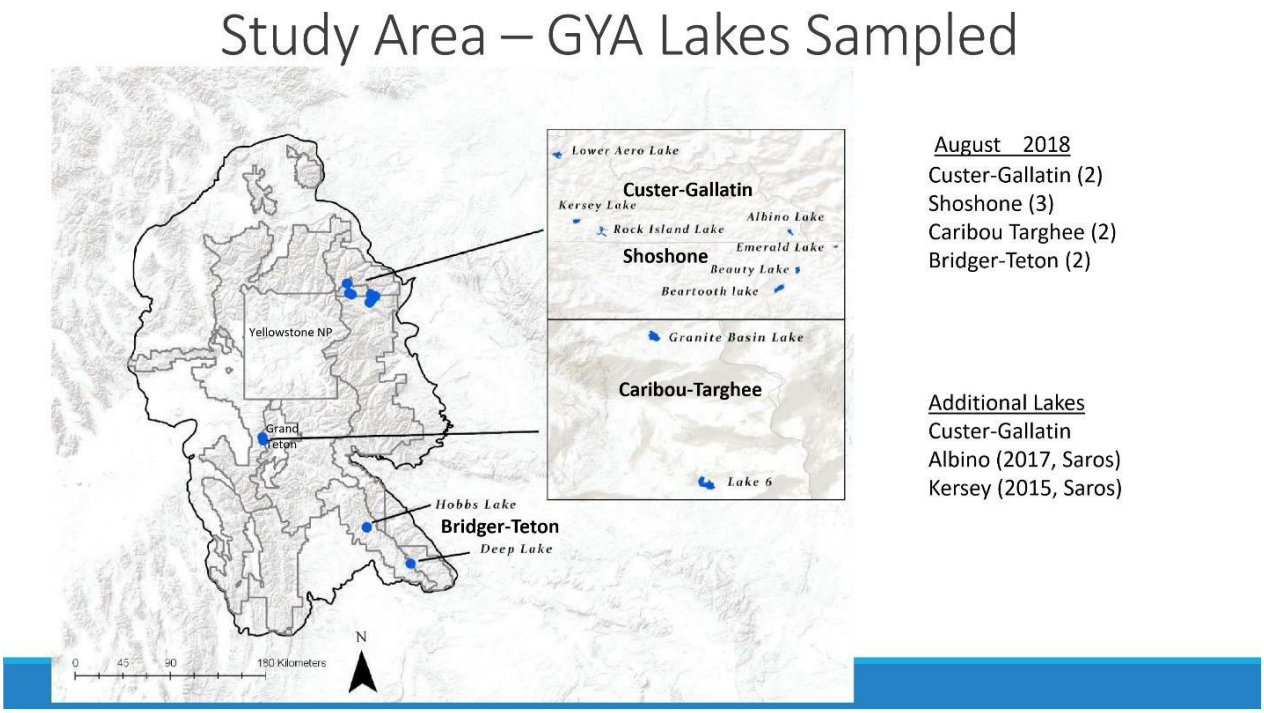

Figure 1: Sampled lake locations within the study area of the greater Yellowstone area taken from most recent surveys in 2018.

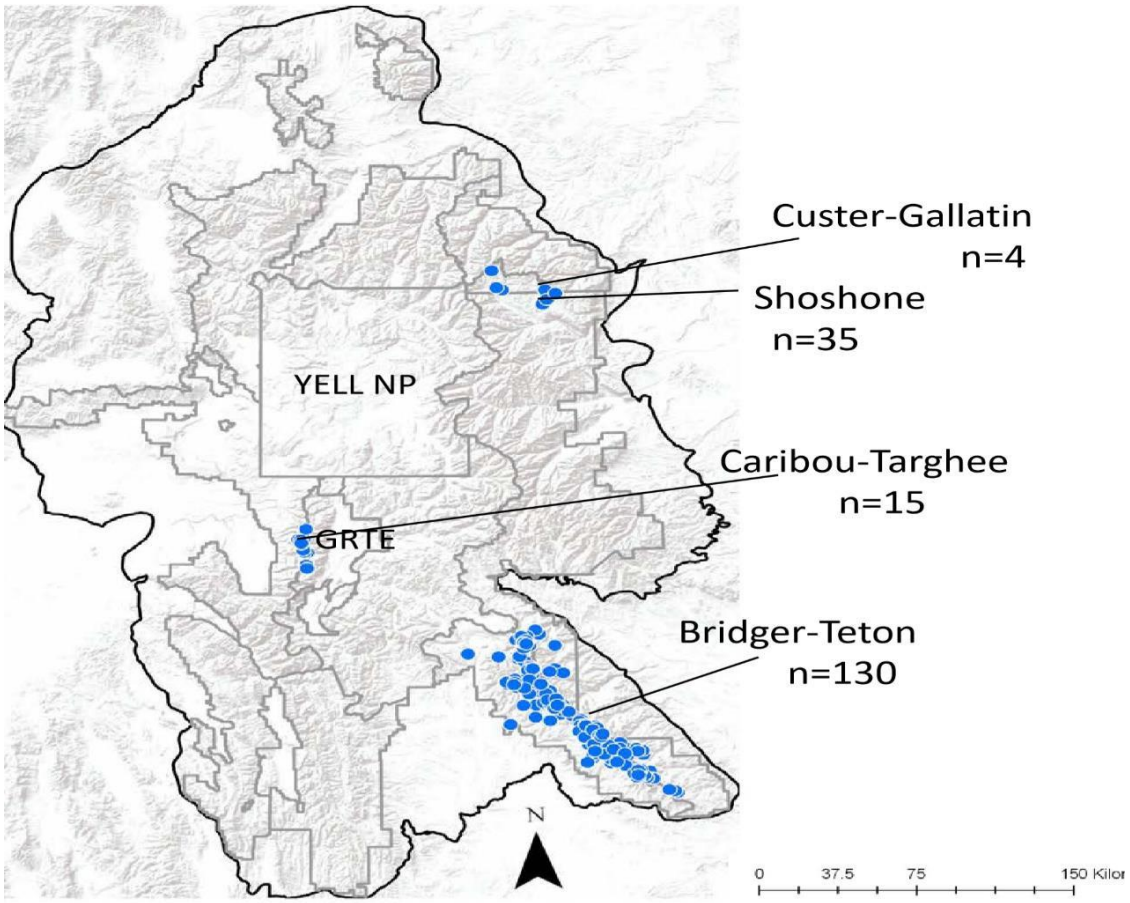

Figure 2: Compiled lake locations of known chemistry data throughout the greater Yellowstone area.